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ScienceDirect
Procedia Social and Behavioral Sciences 2 (2010) 179–185
Procedia
Social and Behavioral Sciences

Security Camera Network, Privacy Protection and Community Safety

Proposal of optical sensor with large area using frosted glass for universal remote controller

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Received October 23, 2009; revised December 3, 2009; accepted December 10, 2009

Abstract

This paper proposed a universal remote controller for social welfare using large area optical sensor. When one of the sensors is indicated with a laser pointer, a signal of remote control is transmitted. The optical sensor with large sensing area can be easily indicated. However, there is a problem that the cost is high to manufacture an optical sensor with large area. Therefore, an optical sensor with large area consisting of frosted glass is developed. By consisting of frosted glass and a small photodetector, the area of the optical sensor can be enlarged easily and the sensor is cheap.

Keywords: frosted glass; optical sensor; laege area; laser pointer; universal remote controller

1. Introduction

Recently, remote controls of electric appliances become complicated, it is hard for some people to perform remote control easily (Kawarazaki et al., 2004). And there is a report that shows what is the most required thing for remote controller is the simplicity of operation (Kodama et al., 2002). Various remote controls are researched that can be easily operated by aged people and physically handicapped person (Koyama et al., 2006). However, such kinds of remote controller cannot be operated easily by a normal person (Yoshida et al., 2007). In almost case, just becomes difficult (Yamamoto et al., 2005). Thus, easily operated remote control for various kinds of people (including aged people, physically handicapped people and normal people) is necessary for social welfare. The study type remote controller that can memorize only a necessary remote control signal is marketed, but it has the limitation in the size and the number of buttons (Hongo et al., 2002). We had proposed a simply operated remote control (Kitazono et al., 2008), which needs a Web camera for signal catching. But some time it does not work well because the Web camera is not a location stable object in daily life. As seen above, a simple constructed remote controller that can be operated easily was not appeared until now.

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1877-0428
10.1016/j.sbspro.2010.01.032

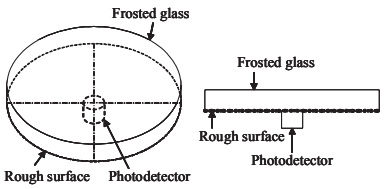


Figure 1. Basic structure of the sensor.

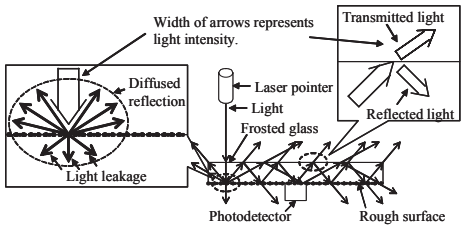


Figure 2. Appearance of reflection in the frosted glass.

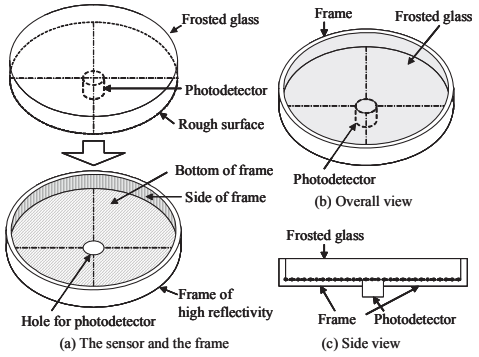


Figure 3. Structure of the sensor and the frame.

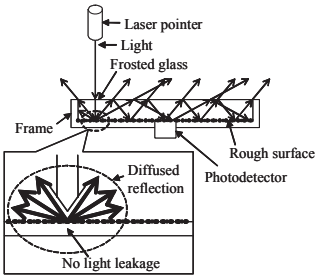


Figure 4. Appearance of reflection in the frosted glass.

This paper proposed a universal remote controller for social welfare using large area optical sensor. When one of the sensors is indicated with a laser pointer, a signal of remote control is transmitted to the electric appliance. The optical sensor which has a large sensing area can be easily indicated with a laser pointer. However, there is a problem that the cost is high to manufacture an optical sensor with large area (Iba et al., 2005). Therefore, it is proposed that the optical sensor with large area using frosted glass. The area of the optical sensor can be enlarged easily by consisting of frosted glass and a small photodetector. The sensor is cheap and can receive light of large area.

2. Optical Sensor with Large Area Using Frosted Glass

2.1. Basic Structure of the Sensor

The basic structure of the optical sensor with large area is shown in Figure 1. A photodetector is arranged in the center of the rough surface of frosted glass. When sensor is irradiated by light, the light reflects diffusely on the rough surface of the frosted glass (Refer to Figure 2). The light repeats reflection in the frosted glass and arrives at the photodetector. Since the photodetector with small area can receive wide-ranging light, the area of the frosted glass corresponds to the light receiving area of the sensor. Therefore, it is easy to make the area of the sensor large.

2.2. Frame

A part of light leaks whenever it reflected to the frosted glass. The light intensity decreases by parting of the distance between an optical detector and the irradiation point. To decrease light leakage, the frosted glass is covered with the frame of high reflectivity (Refer to Figure 3). Appearance of reflection in the frosted glass covered with the frame is shown in Figure 4. The light leakage from the side and bottom of frosted glass is prevented. Therefore, the light intensity in the frosted glass increases and the sensitivity of the sensor becomes high.

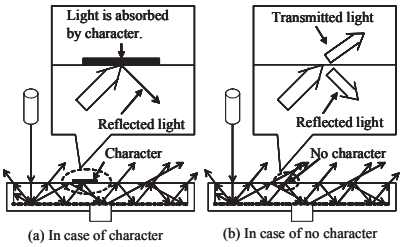


Figure 5. Influence of character on reflection.

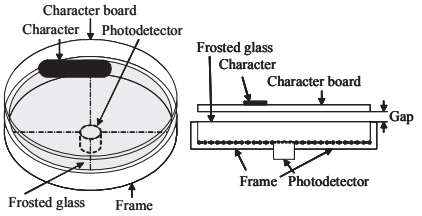


Figure 6. Structure of the sensor and the character board.

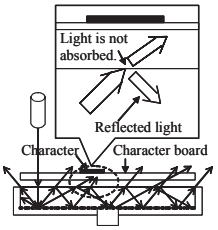


Figure 7. Appearance of reflection in frosted glass.

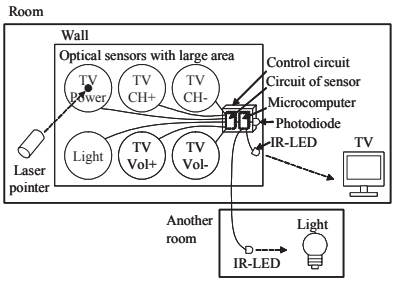


Figure 8. Structure of the universal remote controller.

2.3. Writing of Character

In the universal remote controller, several sensors are used. To distinguish each sensor, characters are written on the surface of the frosted glass. When sensor is irradiated on the position of the character on the frosted glass, the light is hardly incident in the frosted glass because the light is reflected and absorbed by the character. However, there are generally a lot of areas of the position where characters are not written. Thus, the light is incident in the frosted glass by irradiating the light to the position where characters are not written.

2.4. Character Board

When the light reflects at the position of the character, it is absorbed by the character (Refer to Figure 5(a)). Thus, the light intensity in the frosted glass decreases and the sensitivity of the sensor becomes low (Refer to Figure 5). For an improvement of this problem, the character board is set over the frosted glass (Refer to Figure 6). Appearance of reflection in the frosted glass by using the character board is shown in Figure 7. Since the reflection in the frosted glass of Figure 7 agrees with that of Figure 5 (b) on which character is not written, the light in the frosted glass is not absorbed by the character any more, the sensitivity of the sensor does not decrease except the reflection of the character board. Therefore, the sensitivity of the sensor does not become so low.

3. Universal Remote Controller

The structure of the universal remote controller is shown in Figure 8. The optical sensors with large area are prepared. Arbitrary remote control signals are assigned severally to each sensor. They are put on arbitrary place. When one of the sensors is indicated with a laser pointer, a signal of remote control is transmitted from IR-LED. The laser modulates (10[kHz]) because it decreases the influence of the lighting.

4. Experiments

The structure of the sensor with frosted glass shows in Figure 9 (a), in which the parameters are set to l=300[mm], d=5[mm] and Ra (Naruse et al., 2001) =4.0[μm]. It is treated as a standard one to inspect influences that come from the frame setting, changing thickness and roughness of the frosted glass, lighting condition alternating and using the character board. A photodiode (Hamamatsu Photonics, S1226-8BK) is used as a photodetector and a red laser module (Wentai Enterprise, LM-101-A2, 1[mW]) is used as a laser pointer.

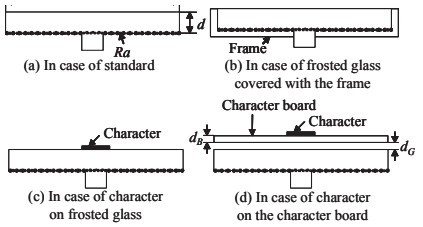


Figure 9. Side view of the sensors used in the experiments.

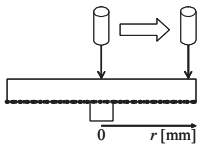


Figure 10. Experimental method.

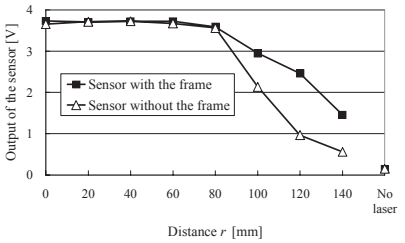


Figure 11. Influence of the frame on output of the sensor.

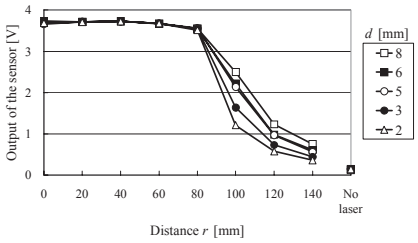


Figure 12. Influence of the thickness on output of the sensor.

4.1. Influence of the Frame

First, influence of the frame is investigated. The output of glass-only sensor (Refer to Figure 9 (a)) is compared with the framed one (Refer to Figure 9 (b)). Frame is made of aluminum with a mirror processed surface. As an experimental method, sensor is irradiated by laser every 20[mm] from center to outside of the frosted glass as shown in Figure 10, and the output of the sensor is measured. The measurement frequency was assumed to be ten times for each irradiation. Experiment was performed in a 300[lux]-illuminated room, and Figure 11 shows result.

The received signal is amplified in order to detect the light even if it is pointed on the boundary area of the frosted glass. This made the output saturated when the laser pointed on the neighborhood of center of frosted glass (Refer to 0~80[mm] of Figure 11), and output value is almost same. However, in the peripheral area of the frosted glass (Refer to 100~140[mm] of Figure 11) difference is observed. The output of the framed sensor (Refer to Figure 9 (b)) is higher than that of the glass-only one (Refer to Figure 9 (a)). It is understood that sensitivity of the sensor becomes high due to the frame. In all location of the sensor, the output (Refer to 0~140[mm] of Figure 11) when the laser is pointed on it is higher than the idling state which is not irradiated with laser (Refer to No laser of Figure 11). Therefore, whether the sensor is irradiated by a laser can be detected.

4.2. Influence of the Thickness

Second, influence of the thickness of the frosted glass (Refer to *d* in Figure 9 (a)) is examined. When the thickness of the frosted glass is changed, the output of the sensor is measured. The thickness (*d*) of 2, 3, 5, 6 and 8[mm] are tried. The experiment is performed in the same condition as described in 4.1. The experimental result is shown in Figure 12.

According as the thickness of the frosted glass is thickened, the output of the sensor increases in the boundary area (Refer to 100~140[mm] of Figure 12). In all location of the sensor, when the laser is pointed on it, the output (Refer to 0~140[mm] of Figure 11) is higher than the idling state which is no laser irradiation (Refer to No laser of Figure 11) whatever the thickness of the glass is. Therefore, whether the sensor is irradiated by a laser can be detected.

4.3. Influence of the Roughness

Then, influence of the roughness of the frosted glass (Refer to *Ra* in Figure 9 (a)) is tested. When the roughness of the frosted glass is changed, the output of the sensor is measured. There are two processing methods for making a rough surface, which are physical abrasion and chemical abrasion. Then, the influence of the processing method of

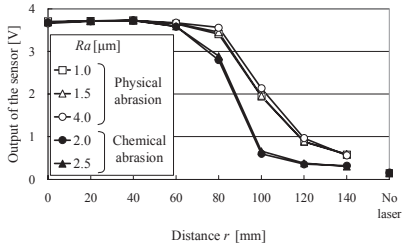


Figure 13. Influence of the roughness on output of the sensor.

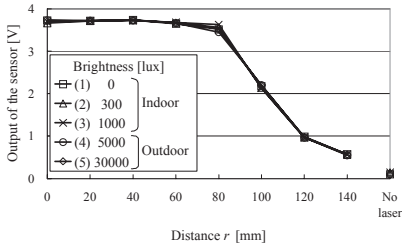
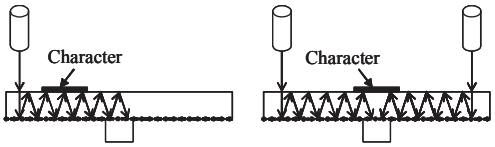
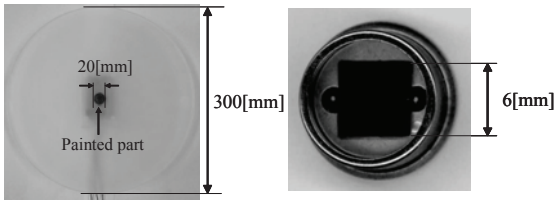


Figure 14. Influence of lighting on output of the sensor.



(a) In case of character placed left side (b) In case of character over the photodetector

Figure 15. Appearance of reflection in the frosted glass.



(a) The optical sensor with large area used in the experiment (b) Part of the photodetector in the sensor

Figure 16. Picture of the sensor and the photodetector.

the rough surface is also examined. The roughness (*Ra*) of frosted glass abraded physically of 1.0, 1.5 and 4.0[μm], and that abraded chemically of 2.0 and 2.5[μm] are tried. The experimental method, the number of the measurement and the experimental condition are the same as 4.1. The experimental result is shown in Figure 13.

It is understand that the output of the sensor consisting of the frosted glass abraded physically is higher than that abraded chemically (Refer to 80~140[mm] of Figure 13). In all location of the sensor, it is also confirmed that the output is not so influenced by the roughness of the glass. In all distance, the output which is irradiated with laser (Refer to 0~140[mm] of Figure 13) is higher than the output which is not irradiated with laser (Refer to No laser of Figure 13). Therefore, it can be judged that sensor is irradiated by laser.

4.4. Influence of Lighting

Next, because lighting keeps changing in daily life, it is necessary to examine the influence of brightness changing. The experiment is performed under follow condition: Lighting of 0 (Darkroom), 300 (Ordinary indoor), 1000(Bright lighted indoor), 5000 (Outdoor but under a shadow) and 30000 (Outdoor under sun) [lux]. The experimental method and the number of the measurement are the same as 4.1. The experimental result is shown in Figure 14.

It is confirmed that the output of the sensor is almost not influenced by the change of lighting. In all distance, the output which is irradiated with laser (Refer to 0~140[mm] of Figure 14) is higher than the output which is not irradiated with laser (Refer to No laser of Figure 14). Therefore, it can be judged that sensor is irradiated by laser.

4.5. Influence of the Character Board

Finally, influence of the character board is investigated. The output of sensors that constructed respectively as shown in Figure 9 (c) and Figure 9 (d) is compared. An acrylic board (Light transmission is 93[%] and the thickness is d_B=2[mm]) is used for the character board. The gap of the frosted glass and the character board is d_G=2[mm].

When character is written directly on the surface of frosted glass, it is observed that the sensitivity was influenced, especially when the character is located between the photodetector and laser irradiation point. In experiment, such condition is made intentionally by wrote a "●" mark on the center of the frosted glass (Refer to Figure 15 (b)). Therefore wherever the laser is pointed on the sensor area, it will be absorbed strongly. This is a worst case assumption for limit test.

The picture of the optical sensor with large area and the photodetector used in it is shown in Figure 16. In addition, the output of the sensor changes because absorption of light is different by the color of the character. In the universal remote controller, it is assumed that users write characters with an arbitrary color because the color of the

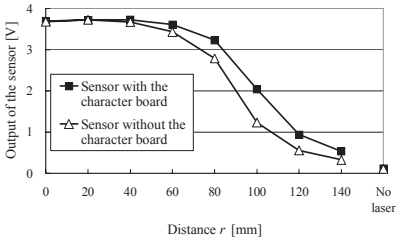


Figure 17. Influence of the character board on output of the sensor.

Figure 18. Picture of the sensor used in the experiment.

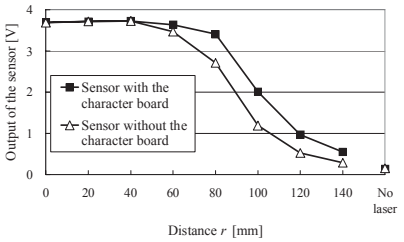


Figure 19. Influence of the character board on output of the sensor.

Figure 20. Picture of the sensors used for operation check.

character is not limited. Black color absorbs light most, so we wrote a black color character in experiment. The experimental method, the number of the measurement and the experimental condition are the same as 4.1. The experimental result is shown in Figure 17. The output of the sensor constructed according to Figure 9 (d) is higher than that of Figure 9 (c).

It is thought that the output of the sensor is different when writing different characters and pictures. However, writing the character directly on the frosted glass will decrease the output more than that of writing the character on a character board. Also additional experiment is performed when different characters (Refer to Figure 18) were written. As an experiment method, laser irradiated every 20[mm] from center to outside of the frosted glass in the direction of arrow "⇒" shown in Figure 18, and the output of the sensor is measured. The number of the measurement and the experimental condition are the same as 4.1. The experimental result is shown in Figure 19. A result similar with Figure 17 is obtained.

As a result, it is proven that sensitivity of the sensor does not decrease so much if character is written on a transparent board.

4.6. Operation Check of the Universal Remote Controller

In the experiment, operation check of the universal remote controller is performed. In all the results, the maximum output of the sensor is 0.15[V] when no laser irradiation, and the minimum output of the sensor is 0.29[V] when sensor is irradiated. Then, it is decided that threshold voltage (V_{th}) of the output of the sensor to judge whether sensor is irradiated or not is 0.20[V]. First of all, four large area optical sensors were prepared. The signal of "Power", "Input switch", "Channel up", and "Channel down" of the television is studied respectively, and the signals are assigned to each sensors. The picture of the sensor used in the experiment is shown in Figure 20. Next, each sensor is directed with a laser pointer, and whether the remote control signal is correctly transmitted is confirmed. The distance between the sensor and operator is 1, 3, 5, and 10[m]. It is tested by 10 people, and each sensor is irradiated 5 times at each distance. The experimental condition is the same as 4.1. Consequently, it operates without the malfunction, and the recognition rate of 100% is obtained.

5. Conclusions

In this paper, we proposed a universal remote controller for social welfare and an optical sensor with large area using frosted glass. The area of the sensor can be enlarged easily by consisting of frosted glass and a small photodetector. Then, the sensor is cheap and can receive light of large area. In the remote controller, when one of the

sensors is indicated with a laser pointer, a signal of remote control is transmitted. Therefore, the remote controller is simply operated.

This research was partly supported by Grant-in-Aid for Scientific Research (C), 19500478.

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